

DEPARTMENT OF ENERGY  
FY 2002 CONGRESSIONAL BUDGET REQUEST

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

CENTRAL SYSTEMS

I. **Mission Supporting Goals and Objectives:**

As the growing national economy relies increasingly on electronically and digitally controlled processes, electricity supply availability becomes a major concern, especially as the electricity generation market is undergoing restructuring. This has resulted in a growing national need for increased electricity and reduced emissions from electric power generation plants to replace and augment an aging power generation infrastructure. Electricity demand from both natural gas and coal is projected to increase significantly through the year 2015 to meet increased energy demand in the U.S. and offset the decline in generation from nuclear power (Annual Energy Outlook, 2001).

Traditionally, electric power generation generally implies large-scale production of electric power in stationary plants that are interconnected by a transmission and distribution system to serve the electric loads in a given area or region. This centralized mode of generation is comprised chiefly of fossil fueled power plants that have rapidly proliferated to meet growing demands. But technology has improved too slowly to keep abreast of societal needs for higher efficiency and reduced environmental impacts.

In response to these needs, the Central Systems Program is focused on improving the existing fleet's performance and to provide innovative technology to support a longer term goal of dramatically improving the efficiency of power systems while reducing emissions of pollutants to near zero levels. In FY 2002, and future years this activity, will be included in the Clean Coal Power Initiative. The near-term focus will continue to develop low-cost technologies. In support of the long term goal, a revolutionary approach called "Vision 21" will continue with the aim of developing technology for high efficiency energy plants with practically zero emissions. Vision 21 is a program that will provide the necessary technology in building blocks along with the integration of these building blocks to attain this goal. A fleet of these Vision 21 plants will be flexible enough to use a variety of fossil resources including coal (our most abundant domestic fuel), natural gas, and other feedstocks. They will produce a slate of energy products including electricity, clean fuels

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and chemicals, and high grade heat. In some cases, these plants will be able to separate and capture CO<sub>2</sub>, a greenhouse gas, for subsequent sequestration.

As part of the current core DOE Fossil Energy RD&D Program, the Central Systems program is addressing the development of cost-effective power systems, based on both coal and natural gas individually and in combination, that are substantially cleaner and more efficient than systems in use today. The Central Systems program includes several advanced power systems based on coal combustion or coal gasification, advanced environmental control technologies, and advanced gas turbine technology. In addition, Central Systems is pursuing a power plant improvement initiative that demonstrates advanced coal-based technologies for improving performance and capacity of new and existing plants. Different kinds of power systems are being developed, each based on a different technology: advanced combustion; gasification combined cycle; pressurized fluidized bed combustion; hybrid combustion systems; advanced turbine systems; and fuel cells in combination with turbines as a hybrid power module. Many of these technologies will evolve into the technology building blocks for Vision 21 while finding applications in related markets along the way, resulting in nearer-term spinoff benefits as well as reducing costs and technical risks for Vision 21 systems.

The program elements for Central Systems include technology developed for existing plants, advanced systems, and Vision 21.

Innovations for Existing Plants - This program element has a near-term focus on developing advanced clean/efficient power systems and highly efficient, cost-effective environmental control technologies for retrofitting to existing powerplants, with applications to new plants as well. Results of this advanced research are used by those who develop, design, manufacture and operate both existing and advanced systems across the entire spectrum of coal utilization technologies not only to improve efficiencies, but also to improve environmental performance. This program's crosscutting efforts address the cost-effective removal of pollutant causing contaminants from fossil fueled systems. It focuses on the development of emissions control technology for SO<sub>2</sub>, NO<sub>x</sub>, air toxics and particulates to address the energy and environmental demands of the post-2000 timeframe; development of high quality scientific information on emerging environmental issues such as the impact of powerplants on water quality and availability, for decision makers; development of emission controls with saleable byproducts to minimize or eliminate liquid/solid wastes from coal-fired powerplants; and sampling and characterization of advanced power system byproducts. A major thrust of this program area is the development of technology to comply with the requirements of the Clean Air Act Amendments (CAAA) of 1990 and new or pending regulations. The FY 2002 budget request

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emphasizes development of retrofit NO<sub>x</sub> control technologies for compliance with the NO<sub>x</sub> SIP Call, TRI acid gas control, 316(b) cooling water intake requirements, and new PM<sub>2.5</sub> and ozone National Ambient Air Quality Standards for essentially all existing coal-based power plants, determining PM<sub>2.5</sub> source-receptor relationships as they relate to coal-fired power plant emissions, field testing of air toxics (mercury) control technologies, and characterization of coal-combustion byproducts.

Low-Emission Boiler System (LEBS) - These systems take pulverized coal combustion, the most widely accepted technology for coal-fired generation at the present time, a major step forward by redesigning the process to gain major performance improvements. The LEBS integrates methods of emission control with a super critical steam cycle at the outset of design. This results in powerplants with very low emissions and significantly higher efficiency than a conventional pulverized coal power plant. This program will continue to completion with prior year funds.

Indirect Fired Cycle (IFC) - IFC systems are coal-fired combined cycle systems that produce energy cleanly and efficiently. The IFC program focused on High Performance Power Systems (HIPPS) incorporates a new high temperature advanced furnace and pyrolyzer which integrates combustion, heat transfer and emission control processes. In FY 2002, the applicable combustion technology for Vision 21 is folded into the Vision 21 gasification/combustion hybrid concepts under the Pressurized Fluidized Bed program.

Integrated Gasification Combined Cycle (IGCC) - The IGCC program fosters the development and commercialization of fuel flexible gasification-based processes for converting carbon-based feedstocks to electricity, steam, and a broad range of chemicals and clean fuels. Compared with today's technologies for power generation, IGCC offers the potential for significant increases in thermal efficiency as well as significant reductions in capital costs and near-zero emissions of pollutants. IGCC is an advanced power generation technology that can readily co-produce electricity and other valuable products. In order to achieve the full potential of IGCC, significant advances must be made to reduce the capital and operating and maintenance costs and to improve both the reliability and the overall system availability, while targeting efficiencies of greater than 60% and reducing environmental emissions to near-zero levels. In FY 2002, the program will continue its focus on cost and efficiency improvements and performance optimization for power generation and co-production applications; gas stream purification to meet quality requirements for use with fuel cells and conversion processes; hybrid and advanced gasification concepts for feedstock flexibility and CO<sub>2</sub> capture; and the development and demonstration of technologies for producing hydrogen and reducing greenhouse gas emissions, all of which are key technology building blocks for Vision 21. The IGCC

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program will be coordinated with other Departmental elements focusing on the production of fuels and chemicals from synthesis gas and the sequestration and utilization of carbon dioxide. The successful accomplishment of these activities will enhance the commercialization prospects of advanced IGCC technologies for the production of electricity for use by utilities, independent power producers, and other industrial stakeholders. It also provides technologies for the coproduction of power and other valuable commodity products that would be characteristic of a Vision 21 plant.

Pressurized Fluidized Bed (PFB) - Although PFB technology has shown technical promise, including high combustion and heat transfer efficiency inherent to fluid beds; sulfur dioxide removal integral to the combustion process through introduction of sorbent into the fluid bed; and low NO<sub>x</sub> emissions, alternate technology pathways such as combustion hybrids appear to have even more promise and reduced risks in achieving the efficiency, environmental and cost goals for advanced, flexible combustion power systems. There, the PFB program is in transition in order to provide the necessary technology base for a Vision 21 concept option for a gasification/combustion hybrid. In FY 2002 the major emphasis at the Wilsonville Power System Development Facility will be the development of design concepts applicable to combustion technology for Vision 21. This project provides the key technology for gasification/fluid bed combustion hybrids for Vision 21 concept options.

The **Power Plant Improvement Initiative** (PPII) focuses on demonstrating advanced coal-based power technologies to improve overall plant efficiency, emissions reduction, cost effectiveness and enhanced reliability. The PPII initiated in FY 2001 and implemented in FY 2002 is the initial investment towards this goal. It is a 50% cost-shared program that will demonstrate and deploy these coal-based technologies over the next few years to enhance electricity supply availability and improve environmental and plant performance. It also has a repayment provision that includes repayment in the replication of the technology demonstrated both domestically and internationally. In FY 2002, and future years, continuing demonstration activity will be included in the Clean Coal Power Initiative.

**Vision 21** is an extension or continuation of ongoing advanced power systems R&D to lower the cost and improve the environmental performance and efficiency of coal plants. This development effort will lead to the deployment of a family of plants that converts a combination of feedstocks (e.g., coal, natural gas, biomass, and opportunity fuels such as, petroleum coke or heavy oil resid (refinery wastes)) to electricity, heat (e.g., steam), and a suite of high-value products that may include synthesis gas, hydrogen, liquid fuels, chemicals, and by-products (e.g., sulfur and ash or slag). The specific feedstocks and products, and indeed the size and configuration, of

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each Vision 21 plant will depend on the plant's location, and on the resources, raw materials, and market factors in play at that location. Physically, Vision 21 plants will be a tightly integrated combination of power and fuels processing subsystems or modules that could include advanced combustors and gasifiers; high-temperature heat exchangers; gas separation, reforming, cleanup, and purification systems; turbines; fuel cells; chemical reactors; and advanced control systems. Vision 21 plants will effectively remove environmental constraints as an issue in the use of fossil fuels: emissions of traditional pollutants, including smog and acid rain forming species, will be near zero and the greenhouse gas, carbon dioxide, will be reduced 40-50% by efficiency improvements, and reduced to zero if coupled with sequestration. Vision 21 plants will be affordable: costs will be compatible with sustained economic robustness, enhanced industrial competitiveness, and jobs creation through the availability of low-cost energy. In FY 2002, Vision 21 will continue the development of key enabling technologies, supporting R&D, and systems analyses, simulations and integration through the government/industry/laboratory/university cost-shared partnership based on the Vision 21 technology roadmap.

Central Systems FY 2002 Performance Measures:

Innovations for Existing Plants - Technologies are being developed to enable existing coal-fired powerplants to comply with ozone and PM<sub>2.5</sub> ambient air quality standards at lower cost.

- Complete Phase I ambient PM<sub>2.5</sub> characterization report.
- Make selections of research projects under the second round Emission Control Byproducts Consortium solicitation.
- Continue research projects for field testing mercury control technologies.
- Complete evaluations of several advanced NO<sub>x</sub> control technologies.

Advanced Systems - Advanced Systems are being developed to significantly reduce emissions by 2015 by: (1) developing market-ready coal power systems with efficiencies over 60 percent and near zero emissions; and (2) integrating advanced turbine and fuel cell technology to achieve market-ready gas-fueled powerplants with efficiencies over 70 percent. Potential benefits from these technologies are potential savings in cost of electricity of \$0.5 billion per year by 2015 reaching \$2.5 billion per year in 2030; generating more than 400,000 jobs per year by 2030; and contributing to powerplant sales of \$10 billion per year in 2030. By 2030, more efficient power

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plants could reduce greenhouse gas emissions in the U.S. by 35 million tons per year of carbon avoided and 88 million tons of carbon per year avoided worldwide.

- Complete initial tests of the IGCC transport gasifier in an oxygen-blown mode to prepare the way for testing of Vision 21 technologies for concentrating CO<sub>2</sub>; prepare a report of results; and evaluate performance to confirm the feasibility of the technology to significantly improve reliability, cost effectiveness, and improved efficiency compared to existing technologies as a long-term goal.
- Complete experimental testing to define the operating parameters of the CO<sub>2</sub> hydrate process and initiate the design of an integrated skid-mounted unit for evaluating the feasibility of effectively separating hydrogen and CO<sub>2</sub> from shifted syngas to meet the long-term goals of providing low-cost hydrogen for high-efficiency fuel cells and for concentrating CO<sub>2</sub> streams for sequestration.
- Complete preliminary design and economic analysis of an air-blown gasification system based on prior experimental data at the Power Systems Development Facility (PSDF) to provide Southern Company the basis for reaching a decision on whether to proceed to a commercial unit.

II. A. **Funding Schedule:**

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>\$Change</u>	<u>%Change</u>
Innovations for Existing Plants	\$14,393	\$20,102	\$18,000	\$-2,102	-10%
Advanced Systems					
Low-Emission Boiler System (LEBS)	1,955	0	0	0	0%
Indirect Fired Cycle	6,869	5,997	0	-5,997	100%
Integrated Gasification Combined Cycle	34,415	35,134	35,000	-134	0%
Pressurized Fluidized Bed	11,971	12,175	8,000	-4,175	-34%
Turbines	<u>43,085</u>	<u>30,936</u>	<u>0</u>	<u>-30,936</u>	<u>-100%</u>
Subtotal, Advanced Systems	98,295	84,242	43,000	-41,242	-49%
Power Plant Improvement Initiative	<u>0</u>	<u>94,791</u>	<u>0</u>	<u>-94,791</u>	-100%

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<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>\$Change</u>	<u>%Change</u>
Total, Central Systems	<u>\$112,688</u>	<u>\$199,135</u>	<u>\$61,000</u>	<u>\$-138,135</u>	<u>-69%</u>

II. B. **Laboratory and Facility Funding Schedule:** CENTRAL SYSTEMS (Cont'd)

	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>\$Change</u>	<u>%Change</u>
Oak Ridge National Lab	\$1,804	\$670	\$400	\$-270	-40%
Idaho Ntn'l Engineering & Environmental Lab	0	90	0	-90	-100%
Argonne National Lab (East)	981	1180	600	-580	-49%
Lawrence Berkeley National Lab	250	200	0	-200	-100%
Lawrence Livermore National Laboratory	0	2000	0	-2,000	-100%
Los Alamos National Lab	850	973	1,000	27	3%
National Energy Technology Laboratory	14,705	13,469	7,400	-6,069	-45%
All Other	<u>94,098</u>	<u>180,553</u>	<u>51,600</u>	<u>-128,953</u>	<u>-71%</u>
Total, Central Systems	<u>\$112,688</u>	<u>\$199,135</u>	<u>\$61,000</u>	<u>\$-138,135</u>	<u>-69%</u>

III. **Performance Summary:**

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Innovations for Existing Plants	Super Clean Systems: Determine cost and performance of retrofittable NO <sub>x</sub> control for superclean systems technologies to meet all Clean Air Act Amendment I and IV requirements. (\$2,458) (TBD)	Super Clean Systems: Continue development of cost effective retrofittable NO <sub>x</sub> control for superclean systems technologies to meet all Clean Air Act Amendment I and IV requirements. (\$1,995) (TBD)	Super Clean Systems: Continue development of cost effective retrofittable NO <sub>x</sub> control for superclean systems technologies to meet all Clean Air Act Amendment I and IV requirements. (\$1,500) (Alsom Power, B&W)
	Fine Particulate Control/Air Toxics: Improve measurement	Fine Particulate Control/Air Toxics: Determine and model	Fine Particulate Control/Air Toxics: Determine and model



III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Innovations for Existing Plants (Cont'd)	characterization techniques for toxic emissions and PM <sub>2.5</sub> from powerplants and other sites to optimize cost and efficiency of control technologies. Develop and field test lower-cost retrofit technology for control of precursor emissions which cause fine particulates. (\$7,026) (TBD)	ambient PM <sub>2.5</sub> concentrations as they relate to sources and receptors of PM <sub>2.5</sub> from coal-fired power plants, obtain field test data for toxic emissions from powerplants and other sites to optimize cost and efficiency of control technologies. Develop and field test lower-cost retrofit technology for control of precursor emissions which cause fine particulates. (\$7,124) (ATS, TBD)	ambient PM <sub>2.5</sub> concentrations as they relate to sources and receptors of PM <sub>2.5</sub> from coal-fired power plants, in order to optimize cost and efficiency of control technologies. Develop and field test lower-cost retrofit technology for control of fine particulates, acid gases, and also for controlling mercury and other air toxics. (\$11,100) (ATS, ADA, B&W)
	In-House: Conduct supporting research in by-product characterization in areas such as emissions control, air toxics and fine particulate control, and CO <sub>2</sub> control and provide for customer service and business activities. (\$3,244) (NETL, BRSC)	In-House: Conduct supporting research in areas such as super clean emissions control, air toxics and fine particulate control, by-product characterization, and provide for customer service and business activities. (\$3,292) (NETL, TBD)	In-House: Conduct supporting research in areas such as air toxics and fine particulate control, by-product characterization, and provide for customer service and business activities. (\$3,300) (NETL, TBD)
	Conduct joint industry/government R&D activities to maximize use of coal utilization combustion byproducts; develop	Conduct joint industry/government R&D activities to maximize use of coal utilization combustion byproducts; develop	Conduct joint industry/government R&D activities to maximize use of coal utilization combustion byproducts; develop

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

Activity	FY 2000	FY 2001	FY 2002
Innovations for Existing Plants (Cont'd)	<p>novel approaches to utilize waste from flue gas desulfurization; conduct evaluations of low NO<sub>x</sub> burner and multi-fuel combustion byproducts for market specifications; facilitate technology transfer. (\$1,519) (TBD)</p> <p>No activity. (\$0)</p> <p>No activity. (\$0)</p>	<p>novel approaches to utilize waste from flue gas desulfurization; conduct evaluations of low NO<sub>x</sub> burner and multi-fuel combustion byproducts for market specifications; facilitate technology transfer. (\$1,547) (TBD)</p> <p>Vision 21: Develop advanced materials for enhancing power plant efficiency including supercritical cycles applicable to Vision 21. (\$1,991) (TBD)</p> <p><b>International Clean Energy Initiative:</b> Transfer best practice of optimizing the performance of coal-fired power plants for mitigation of climate change gases. Further develop technology collaboration and business opportunities between China, Turkey, other countries and U.S. organizations. Develop improvements in plant performance, availability, and</p>	<p>novel approaches to utilize waste from flue gas desulfurization; conduct evaluations of low NO<sub>x</sub> burner and multi-fuel combustion byproducts for market specifications; facilitate technology transfer. (\$1,500) (TBD)</p> <p>Vision 21: Develop advanced materials for enhancing power plant efficiency including supercritical cycles applicable to Vision 21. (\$420) (TBD)</p> <p>No activity. (\$0)</p>

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Innovations for Existing Plants (Cont'd)		maintenance. Disseminate results from U.S. R&D program via publications, workshops and seminars. (\$988) (TBD)	
	No activity. (\$0)	Fund technical evaluations of options for an improved U.S. Capital Power Plant. (\$988) (TBD)	No activity. (\$0)
	No activity. (\$0)	Funding testing of Electrocatalytic Oxidation Technology. (\$1,976) (TBD)	No activity. (\$0)
	Fund technical and program management support. (\$146)	Fund technical and program management support. (\$201)	Fund technical and program management support (\$180)
	\$14,393	\$20,102	\$18,000
Advanced Systems-Low-Emission Boiler System (LEBS)	Continue Phase IV which includes the construction and operation of a proof-of-concept facility. Goal is 42% plant efficiency, SO2 and NOx emission less than 1/6 of NSPS and minimal solid waste. Cost sharing of 50% required in Phase IV. (\$1,935) (DB Riley, TBD)	Continue Phase IV, with prior year funds, which includes the construction and operation of a proof-of-concept facility. Goal is 42% plant efficiency, SO2 and NOx emission less than 1/6 of NSPS and minimal solid waste. Cost sharing of 50% required in Phase IV. (\$0) (DB Riley)	Continue Phase IV, with prior year funds, which includes the construction and operation of a proof-of-concept facility. Goal is 42% plant efficiency, SO2 and NOx emission less than 1/6 of NSPS and minimal solid waste. Cost sharing of 50% required in Phase IV. (\$0) (Babcock Borsig

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u> (formerly DB Riley))
	Fund technical and program management support. (\$20)	Fund technical and program management support. (\$0)	No activity. (\$0)
	\$1,955	\$0	\$0
Advanced Systems- Indirect Fired Cycle	Continue HIPPS development on those components and subsystems that are part of the Vision 21 plant. Near-term activities include transition technology to high efficiency concepts with superior levels of environmental performance, high temperature heat exchanger, and novel cycle optimization studies. (\$5,799) (Foster-Wheeler, UTRC, NETL, TBD)	Activity included below.	No activity. (\$0)
	Conduct Vision 21 critical combustion and high temperature furnace modules development and systems design. (\$1,000) (Foster-Wheeler, UTRC, TBD)	Vision 21: Continue HIPPS development on those components and subsystems that are part of the Vision 21 plant. Mid-term activities include coproduction concepts, hybrid cycles, and advanced system integration. (\$5,937)	No activity. (\$0)

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
		(Foster-Wheeler, UTRC, NETL, TBD)	

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<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
	Fund technical and program management support. (\$70)	Fund technical and program management support. (\$60)	No activity. (\$0)
	\$6,869	\$5,997	\$0
Advanced Systems-Integrated Gasification Combined Cycle	<p>Gasification Systems Technology:</p> <p><b>Gasification</b> - Continue development of the transport gasifier and associated particulate control devices. Expand transport reactor data base to co-feeding coal and other low-cost feedstocks. Continue development of improved refractory and high temperature measurement instrumentation. <b>Gas Cleaning/Conditioning</b> - Extend sorbent development for near-zero discharge of SO<sub>x</sub> and NO<sub>x</sub>. Develop baseline performance of the fluid-bed/transport desulfurizer Process Development Unit (PDU) and evaluate candidate sorbents. Begin design for a desulfurization unit at PSDF. Continue R&amp;D on</p>	<p>Gasification Systems Technology:</p> <p><b>Gasification</b> - Continue development of the transport gasifier and associated particulate control devices and demonstrate long-term performance of both in air-blown operations. Transition the transport gasifier to oxygen-blown operations. Develop and verify computational fluid dynamics (CFD) model for the transport gasifier. Extend Power Systems Development Facility (PSDF) feedstock database using low-cost alternative feedstocks in combination with coal. Conduct coupon testing of advanced refractories at clean coal technology sites. Continue investigation of alternative</p>	<p>Gasification Systems Technology:</p> <p><b>Gasification</b> - Continue development of the transport gasifier and associated particulate control devices and demonstrate long-term performance of both under enriched air conditions. Initiate shake down of facilities for oxygen-blown operations at the Power Systems Development Facility (PSDF) and continue evaluation of alternative feedstocks in combination with coal. Modify the transport gasifier computational fluid dynamics (CFD) model for oxygen and enriched air operations and verify performance with data from the PSDF and Transport Reactor Development Unit (TRDU). Continue coupon testing</p>

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Activity	FY 2000	FY 2001	FY 2002
Advanced Systems- Integrated Gasification Combined Cycle (Cont'd)	<p>NO<sub>x</sub> control and HAPS/PM<sub>2.5</sub> emissions. <b>Product/By-product Utilization</b> - Complete testing of the direct sulfur recovery process as PSDF. Continue investigation on improving slag/ash quality and marketability from co-feed operations. (\$18,054) (SCS, UNDEERC, NETL, ANL, RTI, Praxis, TBD)</p>	<p>temperature measurement instrumentation for high temperature gasifier and conduct development and testing at clean coal technology sites. <b>Gas Cleaning/Conditioning</b> - Continue development of high temperature sorbents for fluid bed and transport desulfurization reactors. Develop kinetic data and CFD models for the transport desulfurizer. Perform comparative analysis of fluid bed and transport desulfurization reactors using the Gas Processing Development Unit to provide data for the design of a facility for PSDF. Conduct desulfurization unit design for PSDF. Extend particulate filter development activities to high temperatures, i.e., &gt; 1000° F. Complete baseline environmental monitoring of CCT sites and begin monitoring during hazardous waste processing. <b>Product/By-Product Utilization</b> - Continue testing of</p>	<p>of advanced refractories at suitable gasification sites. Complete initial R&amp;D of advanced temperature instrumentation for high temperature gasifiers and select concepts for scale-up to prototype units for actual gasifier testing. <b>Gas Cleaning/Conditioning</b> - Continue development of high temperature sorbents for fluid bed and transport desulfurization reactors with focus on producing ultra-clean gas and removing contaminants from using alternative feedstocks. Continue development of kinetic data and CFD models for the transport desulfurizer and begin development of a CFD model for a fluid bed desulfurizer. Perform comparative analysis of fluid bed and transport desulfurization reactors using the Gas Processing Development Unit to provide data for CFD model verification and for the design of a facility for PSDF.</p>

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Activity	FY 2000	FY 2001	FY 2002
Advanced Systems- Integrated Gasification Combined Cycle (Cont'd)		the direct sulfur recovery process at PSDF and extend testing to include single-step sulfur recovery process. Continue investigation to enhance the quality of gasification ash/slag from co-feed operations and explore new market applications. Explore concepts for converting SO <sub>2</sub> to marketable products. (\$18,229) (SCS, NETL, UNDEERC, Fluent, CMU, RTI, KBR, Albany, TECO, Dynegy, Weyerhauser, Texaco, ANL, SRI, Praxis, VPI, IET, FluoreScience)	Continue development of novel sorbent and catalytic techniques for removing sulfur. <b>Product/By-Product Utilization</b> - Complete testing of the direct sulfur recovery skid-mounted process unit at PSDF and continue testing of the single-step sulfur recovery process. Expand efforts on ash/slag characterization and marketability, with particular focus on products from gasification of coal with alternative feedstocks. (\$18,238) (SCS, NETL, UNDEERC, Fluent, CMU, RTI, KBR, Albany, TECO, Global, Weyerhauser, Texaco, ANL, SRI, Praxis, VPI, IET, FluoreScience)
	Systems Analysis/Product Integration:	Systems Analysis/Product Integration:	Systems Analysis/Product Integration:
	Complete IGCC and co-production design optimization. Continue co-production pioneer plant feasibility studies. Complete development of	Extend design optimization study to include CO <sub>2</sub> capture and fuel cell technologies. Continue engineering analysis and risk	Complete one Early Entrance Coproduction Plant study and continue the engineering analyses and risk reduction work associated



III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Advanced Systems- Integrated Gasification Combined Cycle (Cont'd)	<p>IGCC market strategy. Evaluate process configurations and establish target performance. Conduct product workshops. Facilitate the formation of partnerships and consortia, identify technology needs and requirements, and interact with customers and stakeholders (\$3,528) (NETL, Mitretek, TBD)</p> <p>Vision 21:</p> <p>Develop gasification and combustion high efficiency energy complexes with near-zero emissions and CO<sub>2</sub> management options. Develop advanced air</p>	<p>reduction activities associated with the Early Entrance Coproduction Plant. Continue market and system analyses for R&amp;D guidance. Provide funding for product outreach and other program related activities. (\$3,981) (NETL, Bechtel, CTC, E2S, Mitretek, Consol, Parsons, Texaco, Dynegy, WMPI, GE, KBR, APCI, Praxair, Dow Corning, Dow Chemical, Siemens-Westinghouse, Methanex, Rentech, SASOL)</p> <p>Vision 21:</p> <p>Develop gasification and combustion high efficiency energy complexes with near-zero emissions and CO<sub>2</sub> management options. Continue development of</p>	<p>with the remaining two projects. Complete gasification design optimization studies incorporating fuel cells and CO<sub>2</sub> capture. Complete U.S. gasification market study for power generation. Continue systems analyses for research guidance and product outreach activities. Conduct industry interviews and develop a long term strategy/roadmap for gasification technology development. (\$3,672) (NETL, Bechtel, CTC, E2S, Mitretek, Consol, Parsons, Texaco, Dynegy, WMPI, GE, KBR, APCI, Praxair, Dow Corning, Dow Chemical, Siemens-Westinghouse)</p> <p>Vision 21:</p> <p>Continue development of hybrid gasification/combustion concepts, focusing on high efficiency, near-zero emissions, and alternative fuels processing. Explore advanced</p>

### III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

Activity	FY 2000	FY 2001	FY 2002
Advanced Systems-Integrated Gasification Combined Cycle (Cont'd)	separation technology and integration with advanced gas turbines. Develop high temperature hydrogen membrane separation technologies for integrated IGCC/fuel cell applications. Develop advanced gas cleanup technologies for ultra-clean synthesis gas for fuel cell and coproduction applications. Conduct experimental investigations on coal/biomass/waste gasification. Perform system analyses for integration of gasification/combustion/fuel cell/advanced turbines/coproduction applications for achieving Vision 21 goals. Develop advanced fuel cell systems for Vision 21 gasification/combustion applications in conjunction with gas-based fuel cells system development. (\$12,481) (APCI, Texaco, ANL, TECO, RTI, TBD)	advanced membrane-based air separation technologies and begin first level of scaleup. Continue development of high temperature membranes for hydrogen separation and CO <sub>2</sub> concentration. Continue development of low temperature technology for hydrogen/CO <sub>2</sub> separation and begin design of skid-mounted test module. Continue development of feed system technologies for co-feeding coal/alternative feedstocks to high pressure gasifiers. Begin shakedown and testing of municipal solid waste processing technology. Continue development of advanced synthesis gas cleaning technologies to achieve high purity gas for fuel cell and synthesis gas conversion applications. (\$12,573) (APCI, Praxair, ANL, NREC, Enertech, Bechtel, LANL, RTI, IGT, Siemens-Westinghouse, NETL, Foster Wheeler, TBD)	gas cleaning technologies required for near-zero emission hybrid facilities. Investigate feasibility of novel gasification concept for producing hydrogen and sequestration-ready CO <sub>2</sub> . Continue with scale-up activities for production and testing of the advanced membrane-based air separation technologies. Continue development of improved materials and module design of high temperature membranes for hydrogen/CO <sub>2</sub> separation and explore fabrication methodologies. Develop high temperature barrier filters that are compatible with hydrogen membrane operations. Continue development of low-temperature technology for hydrogen/CO <sub>2</sub> separation, complete construction of a skid-mounted test module, and begin shakedown testing. Begin construction and testing of novel concepts for co-feeding

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Advanced Systems- Integrated Gasification Combined Cycle (Cont'd)			coal/alternative feedstocks to high pressure gasifiers. Complete shakedown and initiate testing of municipal solid waste processing technology. Complete exploratory investigation of novel advanced gas cleaning technologies and begin bench-scale engineering development to achieve high purity synthesis gas for fuel cell and conversion applications. Expand gas cleaning program to include multi-contaminant control concepts and other novel approaches applicable for multi-feed gasification systems. Continue collaborative efforts to develop models and software for process concepts. (\$12,740) (APCI, Praxair, ANL, NREC, Ceramatec, Texaco, PSU, Penn, Enertech, Bechtel, LANL, RTI, IGT, Siemens-Westinghouse, NETL, REI, FW, TEKES, NFCRC, GEEERC, Princeton, INT, Eltron, Chevron, Coors, INEEL, UC,

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
			ORNL, McDermott, Foster Wheeler, TBD)

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
	Fund technical and program management support. (\$352)	Fund technical and program management support. (\$351)	Fund technical and program management support. (\$350)
	\$34,415	\$35,134	\$35,000
Advanced Systems- Pressurized Fluidized Bed	Continue evaluation of hot gas cleanup filter materials, and systems to refine and validate designs. Evaluate FBC sorbents that reduce consumption with subsequent reduction of CO <sub>2</sub> . Goal is to significantly enhance performance and reduce cost. Perform supporting research such as system dynamics, combustion characterization, and cofiring with carbon neutral fuels. (\$3,920) (NETL, TBD)	Continue evaluation of hot gas cleanup filter materials, and systems to refine and validate designs. Evaluate FBC sorbents that reduce consumption with subsequent reduction of CO <sub>2</sub> . Goal is to significantly enhance performance and reduce cost. Perform supporting research such as system dynamics, combustion characterization, and cofiring with carbon neutral fuels. (\$2,970) (NETL, TBD)	Continue evaluation of hot gas cleanup filter materials to refine and validate designs and reduce consumption with subsequent reduction of CO <sub>2</sub> . Goal is to enhanced performance, reduce costs, and support hybrid systems for Vision 21 (\$700). Continue gas stream cleanup testing at PSDF, Wilsonville (\$3,500). (Total \$4,200) (NETL, Southern Co. Services)
	Evaluate advanced systems users by performing site specific repowering studies that promote repowering of an actual electricity producer's site. (\$150) (TBD)	Evaluate previously selected advanced systems users by performing site specific enhancements that lead to reduced cost and efficiency improvements for the repowering studies that promote repowering of an actual electricity producer's site. (\$550)	No activity. (\$0)

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
		(TBD)	
Advanced Systems- Pressurized Fluidized Bed (Cont'd)	Continue to improve environmental performance and efficiency with emphasis on HAPS control strategies and gas turbine integration. Cycle improvements through the introduction of other technologies like Fuel Cells and super critical steam cycles will be pursued to achieve Vision 21 goals. (\$390) (NETL)	Complete studies of environmental performance and efficiency with emphasis on HAPS control strategies and gas turbine integration. Continue cycle improvements through the introduction of other technologies like Fuel Cells and super critical steam cycles will be pursued to achieve Vision 21 goals. (\$979) (NETL)	No activity. (\$0)
	Continue operation of the APFBC pilot scale project at Wilsonville. (\$7,189) (Southern Co. Services, TBD)	Continue operation of the APFBC pilot scale project at Wilsonville. (\$7,354) (Southern Co. Services, TBD)	Discontinue operation of the APFBC pilot scale module at Wilsonville. (\$0) (Southern Co. Services)
	No activity. (\$0)	No activity. (\$0)	Support the development of design concepts applicable for gasification/fluid bed hybrids for Vision 21. (\$3,200) (Southern Co. Services)
	Explore power systems designs to optimize CO <sub>2</sub> recycle and	Complete power systems designs to optimize CO <sub>2</sub> recycle and	Evaluate gas conditioning subsystems and concepts for

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Advanced Systems- Pressurized Fluidized Bed (Cont'd)	enrichment for CO <sub>2</sub> capture or reduction. (\$200) (TBD)	enrichment for CO <sub>2</sub> capture and reduction. Evaluate fluidized-bed combustion sorbents that reduce consumption with subsequent reduction of CO <sub>2</sub> while reducing cost, increasing temperature and maintaining sulfur capture. (\$200) (NETL, TBD)	Vision 21 systems. (\$520) (NETL, TBD)
	Fund technical and program management support (\$122).	Fund technical and program management support (\$122).	Fund technical and program management support. (\$80)
	\$11,971	\$12,175	\$8,000
Advanced Systems- Turbines	Vision 21: Investigate flexible midsize turbine configurations for Vision 21 powerplex applications including coproduction. (\$710) (General Electric, Pratt and Whitney, Rolls Royce, Siemens-Westinghouse)	Vision 21: Develop enabling technologies for advanced heat engine and turbine cycles including high temperature materials and zero emissions combustion. R&D program for critical technology development, advanced computing, and engine/turbine development. Develop technology for fuel cell/engine hybrid systems, and integration of the ATS into advance coal-fueled power systems. (\$4,963) (Rolls-Royce, Honeywell, General Electric,	No activity. (\$0)

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
		Clean Energy Systems, FuelCell Energy, LLNL, NETL, Reaction Engineering, NFCRC, TBD)	
Advanced Systems-Turbines (Cont'd)	Next Generation Turbines: Conduct advanced cycle studies (\$2,500) (Ramgen Power Systems)	Next Generation Turbines: Continue Next Generation Turbine Systems technology base crosscutting R&D including: Univ./industry Consortium, national laboratory and in-house research, advanced concept development and systems analysis, low emissions combustion, diagnostics and monitoring technologies, sensors/ controls, materials and manufacturing technologies and advanced computing (\$8,534). Conduct R&D and design studies for the next generation turbine systems (\$5,000) (Total \$13,534) (Ramgen Power Systems, Siemens-Westinghouse, CFD Research Corp., Rolls Royce, Pratt and Whitney, General Electric, TBD)	No activity. (\$0)
	Supporting Technologies:	Supporting Technologies:	No activity. (\$0)



III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Advanced Systems-Turbines (Cont'd)	Continue supporting technology for high performance, ultra-low emission, reliable, flexible gas turbine systems. Continue technology base development including: Univ. Consortium, in-house research, manufacturing technologies, address fuel flexibility application. Conduct advanced cycle studies. (\$7,509) (SCIES, NETL, Clean Energy Systems, CFD Research Corp., ORNL)	Conduct supporting technology for high performance, ultra-low emission, reliable, flexible gas turbine systems. (\$3,320) (SCIES, NETL, ORNL, TBD)	
	ATS: Complete full-scale component/sub-system testing and engine manufacturing. Initiate site erection and preparation for full speed test. Conduct full-speed no-load engine tests and ATS system integration. (\$31,924) (GE, Siemens-Westinghouse)	ATS: Complete full speed engine tests, ATS system integration, and component testing. Initiate technical, economic, and environmental performance system studies. (\$8,829) (General Electric, Siemens-Westinghouse)	No activity. (\$0)
	Provide technical and program support. (\$442)	Provide technical and program support. (\$290)	No activity. (\$0)
	\$43,085	\$30,936	\$0

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Subtotal, Advanced Systems	\$98,295	\$84,242	\$43,000

III. **Performance Summary:** CENTRAL SYSTEMS (Cont'd)

<u>Activity</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>
Power Plant Improvement Initiative	No activity. (\$0)	The Power Plant Improvement Initiative will engage in solicitation and pre-award activities for the program in anticipation of release of funds for obligation on Sept. 30, 2001. (\$93,843) (TBD)	Continue PPII project activities with funds not available until Sept. 30, 2001. The (PPII) will fund projects that will demonstrate advanced coal-based technologies applicable to existing and new power plants including co-production plants. These demonstrations will focus on technology that can be commercialized to address electricity reliability through improved capacity, efficiency and environmental performance. (\$0)
	No activity. (\$0)	Fund technical and program management support. (\$948)	No activity. (\$0)
Subtotal, Power Plant Improvement Initiative	\$0	\$94,791	\$0
Central Systems, Total	\$112,688	\$199,135	\$61,000